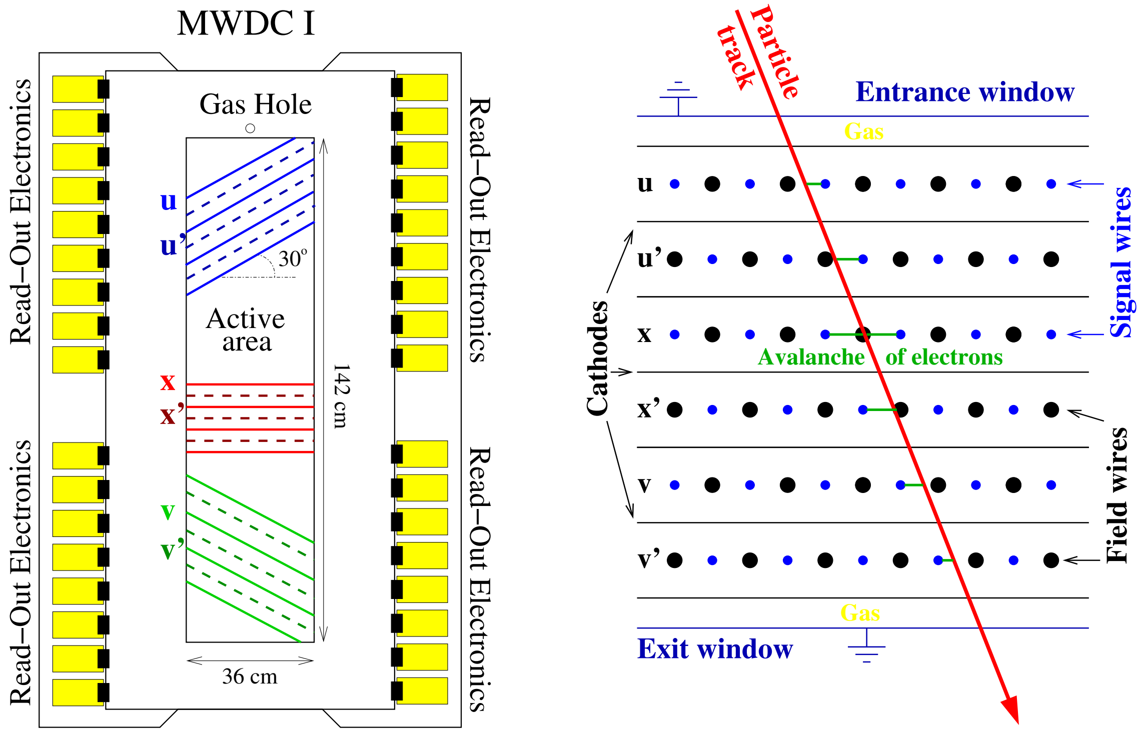

Figure 2.34 — [Left:] Schematics of the first, smaller BigBite's MWDC. The active area of the chamber is $a \approx 140\,\mathrm{cm} \times 35\,\mathrm{cm}$. Figure also shows the orientation of wire planes. The wires in planes (x, x') are aligned horizontally, wires in planes (u, u') are oriented at an angle of 30° with respect to the horizontal direction and the wires of the planes (v, v') are oriented at -30°. The signals from all wires are read-out through the electronic circuit boards mounted on the edges of the chamber. [Right:] Particle tracking through the MWDC. On its path, particle ionizes the atoms in gas. Created avalanches of electrons drift inside the homogeneous electric field to the nearest signal wire. From the positions of the hit wires and drifting time of the avalanches, particle track can then be reconstructed.

the hit wire plane (see Fig. 2.35). The resolution of each wire-plane was determined [75] to be better than 200 μm.

A one-dimensional positional information from all the wire planes of both MWDCs is then used to reconstruct a full track of a particle, that is flying through the detector package. Each track is determined by four coordinates: two positions $(x_{\mathrm{Det}}, y_{\mathrm{Det}})$ at the entrance to the first MWDC and two angles $(\theta_{\mathrm{Det}}, \phi_{\mathrm{Det}})$. They are determined by a dedicated analyzing software [76]. The program first divides hits into three groups (or projections) according to their orientation. Within each projection two dimensional tracks (or roads) are then reconstructed. A search for roads is done by a Pattern Match Tree Search algorithm [77]. An example of reconstructed roads for a given hit pattern in a x-projection of MWDCs is demonstrated in Fig. 2.36. In the last step, roads for all projections are combined into a full three-dimensional tracks. The coordinates of the full track are determined by solving a set of equations using Cholesky decomposition [**?**]:

$$\xi_i = (x_{\mathrm{Det}} + z_i \cdot \tan\theta_{\mathrm{Det}}) \cos\alpha_i + (y_{\mathrm{Det}} + z_i \cdot \tan\phi_{\mathrm{Det}}) \sin\alpha_i \,,$$

where ξ_i is directly measured coordinate in the i-th wire plane, which is positioned at z_i and α_i is the angle of the i-th wire plane with respect to the horizontal (x) axis. The number of successfully reconstructed tracks per event is demonstrated in Fig. 2.37.

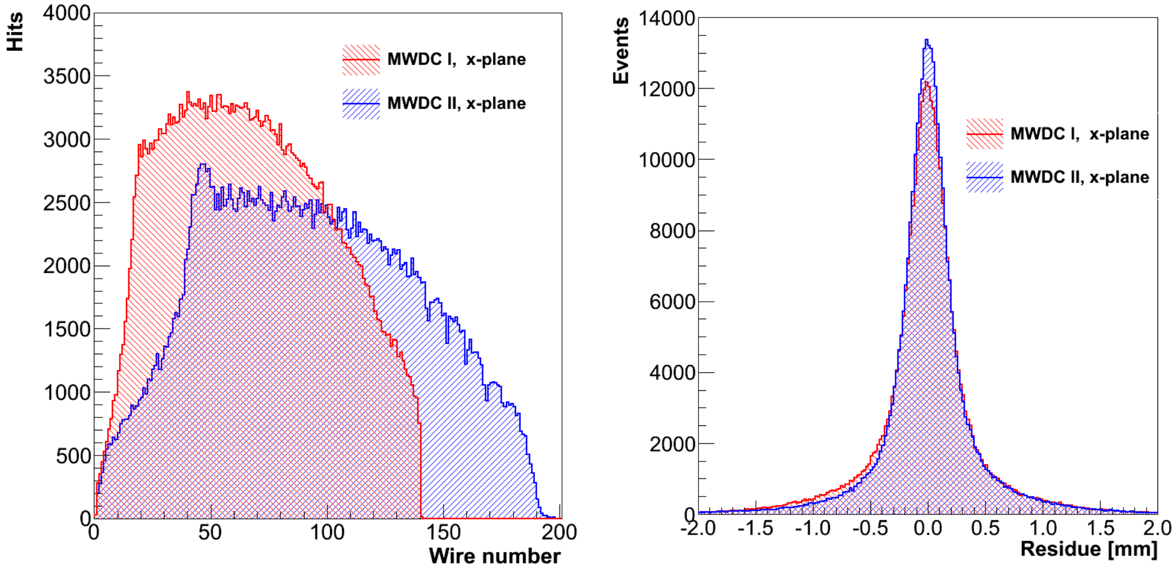

Figure 2.35 — Typical results of the analysis of the MWDC performance. [Left:] Response of wire-plane x as a function of the wire number in the first and second MWDC. [Right:] Spatial resolution of the wire-plane x for both MWDC. The residue is defined as a distance between the hit position and the track projection on the hit wire plane. The spatial resolution of each wire-plane was determined [75] to be better than 200 μm.

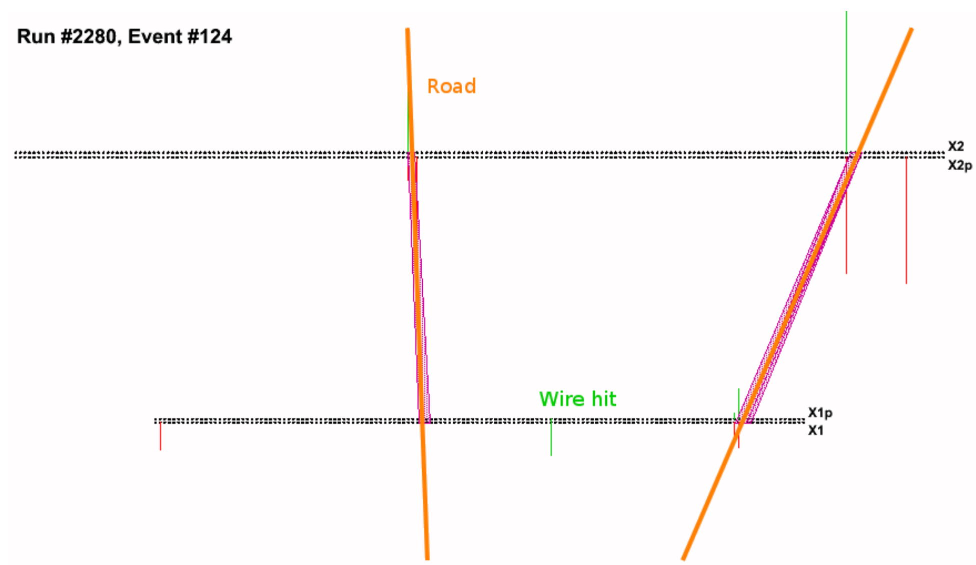

Figure 2.36 — Reconstructed two-dimensional tracks (roads) in the x-projection of MWDCs. Each projection combines four wire planes (e.g. x1, x1p, x2, x2p). Wire hits in each plane are shown with read and green vertical lines. The length of a line corresponds to the distance (not in scale) from the wire. Hits from all wires are introduced to the Pattern Match Tree Search algorithm which finds possible roads. The roads from all three projections (x, u, v) are then combined into three-dimensional tracks.

The particle track parameters are obtained together with the corresponding uncertainties, which are directly related to the MWDC wire-plane the spatial resolution. The resolution for the vertical coordinate x_{Det} was estimated to $\sigma_{x_{\mathrm{Det}}} = 91$ μm, while for hor-

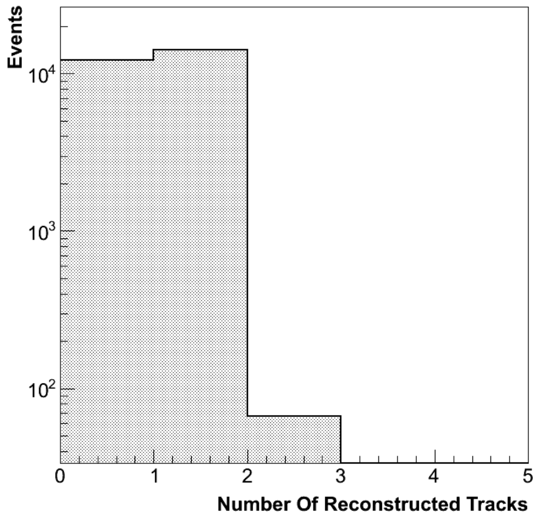

Figure 2.37 — Number of reconstructed tracks in the BigBite MWDCs. There are events for which no track could be reconstructed. These are mostly cosmic events. The majority of coincidence events are with one reconstructed track. Less than 1 % of the events have more than one track.

izontal coordinate y_{Det} was concluded to be $\sigma_{x_{\mathrm{Det}}} = 200\,\mu\mathrm{m}$. The resolution for the x_{Det} is expectingly better because of the wire orientations. Only two planes of wires can be used to determine y_{Det}, while three are considered for x_{Det}. The corresponding angular resolutions are $\sigma_{\theta_{\mathrm{Det}}} = 0.157\,\mathrm{mrad}$ and $\sigma_{\phi_{\mathrm{Det}}} = 0.353\,\mathrm{mrad}$. Again for the same reasons, out-of-plane angle θ_{Det} is determined with better accuracy than in-plane angle ϕ_{Det}.

In the calculation of these errors, uncertainty in the relative positions of the wire-chambers was not considered. It was estimated to be $\approx 0.5\,\%$ and would represent the dominant part of the error. However, since MWDC were not moving during the experiment, it affects only the absolute values of the track angles, which can be compensated by the appropriate correction in the optics matrix.

2.6.3 Scintillation detector

The particle identification (PID) and timing information was provided by scintillation detector (also called the Trigger plane), which was build by University of Glasgow [78]. It consists of two individual layers of scintillation bars (called dE-plane and E-plane) separated by 8 mm. See Fig. 2.38 for details. They are mounted at the back of the BigBite hadron detector package, $\approx$ 10 cm behind the second MWDC. The dE- and E-planes each consist of 24 scintillator bars, made of EJ-204 plastic. The bars and are 50 cm long and 8.6 cm wide. For the dE-plane, thinner bars (0.3 cm) were used to detect low-energy particles, while for the E-plane, a thickness of 3 cm was chosen to allow for the detection of more energetic particles. The light pulses in each bar were detected by Photonis XP2262B photomultiplier tubes (PMTs) mounted at each end of the bar. The PMTs were coupled to the scintillator paddles through the fish-tail light guides made of UV transmitting plexiglass BC800. To double the spatial and momentum resolution, the bars in the E-plane are offset from those in the dE-plane by one half of the bar width (4.3 cm).

A signal from each PMT is first amplified ten times and then divided into three copies. The first copy goes to the trigger electronics to form a trigger pulse, which starts the data reading from all the detectors. The second and the third copy are lead to analog-to-digital converters (ADC) and time-to-digital converters (TDC), where timing